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OPERATION OF CLARA AT DARESBURY LABORATORY AND LLRF ACTIVITIES

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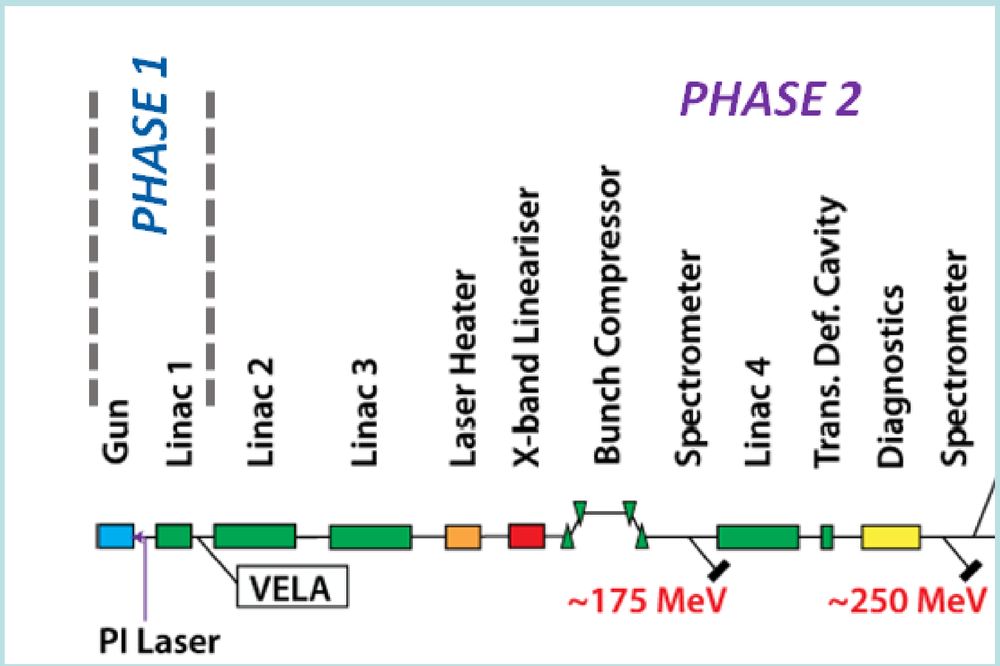
Commercial LLRF system from Instrumentation Technologies Libera LLRF (Itech) used for CLARA machine to provide known performance, costs and achieve project timescales. The systems have proved to be very powerful instrument's to diagnose machine performance. Six Libera LLRF units have been purchased for CLARA , three are currently in operation on the machine with spare units being used to access modulator performance and environmental issues

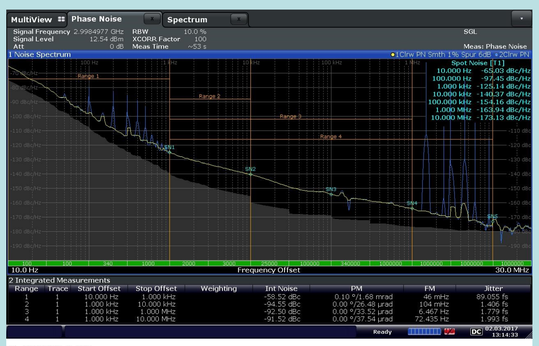
Parameter	Typical value		Stability requirement	
	Value	Unit	Value	Unit
CLARA Machine parameters, Phase-1				
Beam momentum	35	MeV	0.125	%
Bunch charge	70	pC	7	%
Number of bunches per RF pulse	1			
Pulse repetition rate	10	Hz		
Gun RF system Scandinova modulator with Thales klystron				
RF frequency	2998.5	MHz		
RF pulse power (typ)	8	MW	0.01	%
RF phase	(on crest)		0.1	°
RF pulse width (typ)	2.5	µs		
Modulator voltage range	115-190	kV	±0.1	%
Linac-1 RF system DTI modulator with Thales klystron				
RF frequency	2998.5	MHz		
RF pulse power	15	MW	0.01	%
RF phase	(on crest)		0.1	°
RF pulse width (typ)	0.7	µs		
Modulator voltage range	340-375	kV	±0.1	%

RF parameters for the operational part of CLARA

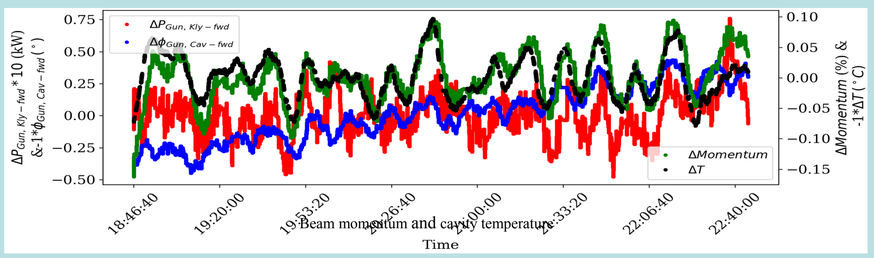


Phase 1 is in operation, Phase 2 is being installed now and will be in operation 2020?

Libera LLRF and Sync 3 reference distribution installed in the LLRF room



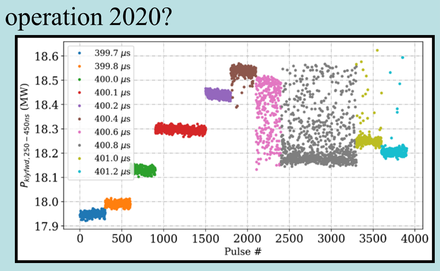
CLARA master oscillator performance



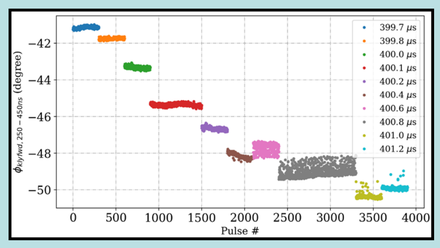
Beam momentum and cavity temperature

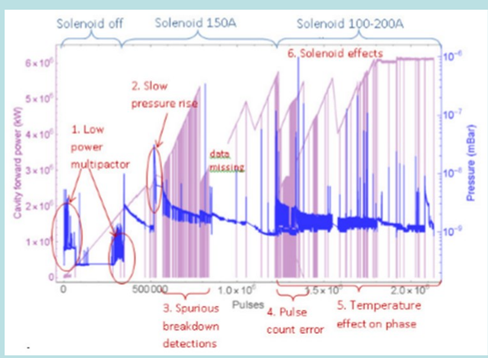
- Analysis of the Gun RF system has found a RF power stability of 0.09% and 0.04 Degrees
- Beam produced by the gun shows a strong correlation in beam momentum +/- 15% with 0.15°C variation in cooling water temperature, this will be improved for the next operation

- Analysis of the linac RF system had shown a number of problems in terms of noise and jitter including RF power spikes of 2.6% at 18MW
- The amplifier system was tested in saturation which improves some of the noise levels
- Also the LLRF is now operated at 90% of its nominal output power
- Spikes in the RF amplitude have been seen on the beam and in the RF system, it is not understood whether this is a HV or klystron problem but has been cured for now by moving the timing back 0.75uS on the HV pulse
- This has reduced RF power jitter to 0.0262% and 0.06 Degrees



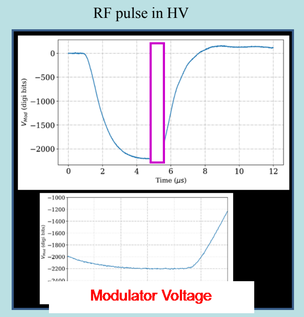
Jitter of RF system WRT HV





Conditioning scripts written in python are used to auto condition the RF cavities with a pre-set breakdown rate

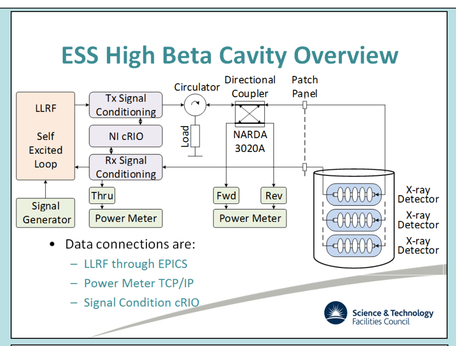
RF pulse in HV

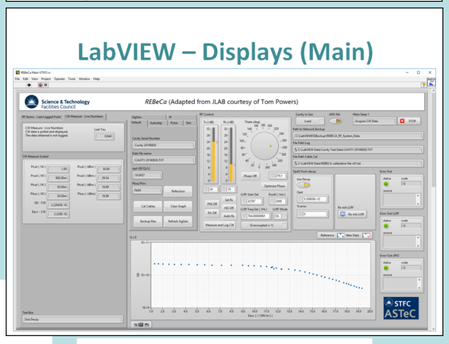


ESS LLRF

As part of the European Spallation Source (ESS), Daresbury Laboratory is tasked with the qualification of the high beta superconducting RF cavities. This has required the construction of a cryogenic system, cryostat and an RF system capable of qualifying the 84 cavities as they are made.

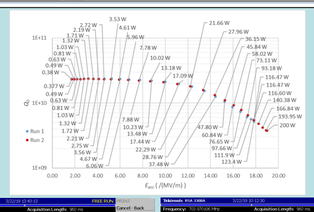
The RF system consists of a Labview control system to drive and record all the signals and measurements from the cavity. An Artix 7 FPGA based LLRF board was manufactured in house and operates a SEL function to lock the cavity. Cavity Q's of around 5*10- 9 are expected.



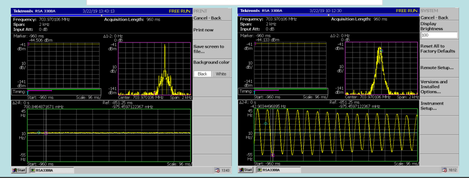


- RF system can be switched to qualify 3 SCRF cavities in one cryostat
- All data is recorded in a filing system so that each cavity has a history of tests
- Calibration routines on each cool down have been established so that cavity gradient can be
- This system was developed with the help of Tom Powers JLab

FPGA board designed in house



Results from Scalay and confirmation of results from Daresbury



Microphonics seen during initial cryogenic commissioning

Quadrature demodulator:
Part: Texas Instruments TRF371109/25/35
Frequency: 0.3 to 1.7 / 0.7 to 4.0 / 1.7 to 6.0 GHz
Bandwidth: 1.4 to 60 MHz

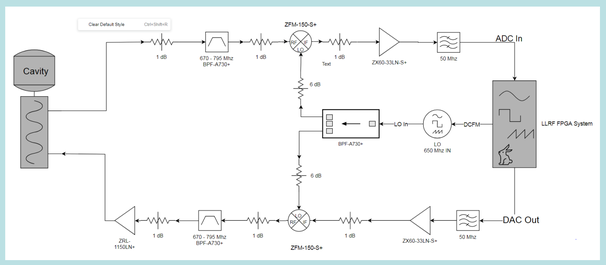
Dual ADC:
Part: Linear Technologies LTC2145-14
Maximum sampling rate: 125 MSps
Resolution: 14 bit

Up to Artix 7 XC7A200T FBG484 or FBV484
Logic cells: 215,360
DSP48E1: 740
36 kb BRAMs: 365

LLRF4 experience

Card was used on ALICE for SCRF and NC cavity feedback. Ramp filling was used to reduce coupler sparking in SCRF couplers

System has been built to operate as a self excited loop (SEL) for operation around 704 MHz as a back up system for the ESS project

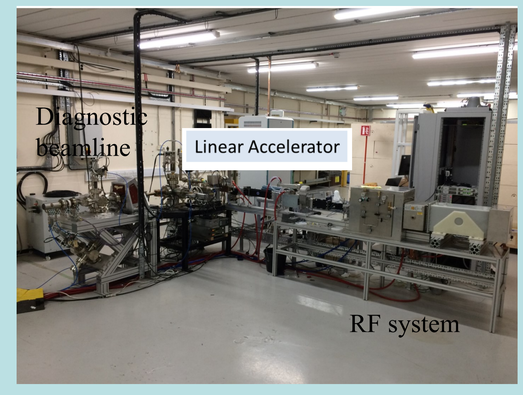


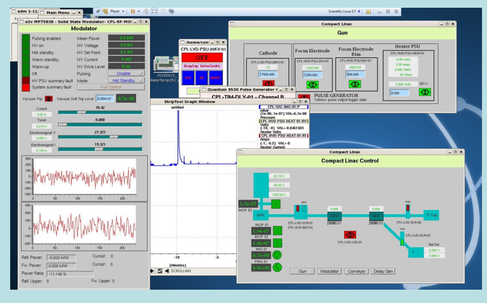
New staff are being encouraged to learn digital technique's using Sparten 6 version of the LLRF4 card

Compact Linac originally built as a test for cargo scanning, now converted for use as a user facility

- S band 2.5MW magnetron
- Pulse length -0.5 to 4uS
- Pulse repetition rate 10 to 200Hz
- Design energy - 3.5 MeV
- Beam current – 40mA accelerated

- Struck SIS8300-KU used as digitiser for RF system





EUROPEAN SPALLATION SOURCE

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